SYSTEM FOR AUTOMATICALLY MACHINING THE ENDS OF ROLL FORMED MATERIAL

I claim benefit of provisional patent application serial number 60/429915 that was filed on Nov 29, 2002.

BACKGROUND ART

Numerous patents have been granted for roll forming machines. Most of these cover one particular configuration such as disclosed in 5,394,722. Some allow for different sizes of material as disclosed in 4,899,566. We are not aware of any that provide for the automatic forming of the end of the workpiece.

SUMMARY OF THE INVENTION

Current technology in the rolled metal forming business (for example rain gutters) requires that operator of the machine measure the work piece as it is output from the forming machine. They must then cut it to the correct length. Typically a shear is included on the machine for this function and will cut the work piece perpendicular to its length. However, if a mitered angle, or other end profile, is desired, the operator must cut it by hand. Due to the complicated cross section of the typical work piece a traditional shear has not been found to be practical. Current techniques require hand cutting or the use of a power saw. Neither of these methods is acceptable. They are time consuming and inaccurate; they also may leave a rough and jagged edge on the work piece. This invention solves the problem by cutting the desired angle before forming the work piece into the final shape. Historically, this would be almost impossible since the operator wouldn't be able to easily measure the correct length. By adding a computer that is interfaced to a length measuring sensor, the computer can make all the necessary calculations and determine exactly where the proper profile should be cut prior to roll forming the metal. This will greatly reduce the operator's workload, increase safety, reduce wasted material, reduce the time required per work piece and enhance accuracy.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows the enhanced rolled metal forming machine.

Fig. 2 is a system level block diagram of the invention.

Fig. 3 is an enhanced implementation with dual drive motors

Fig. 4 is a system level block diagram of the dual drive motor embodiment

Fig. 5 shows the invention as an addition to an existing roll forming machine

Fig. 6 is a typical cross section of a roll form rain gutter.

Fig. 7 shows shear/cut lines to be implemented before the forming of the metal.

Fig. 8 is a typical Computer controlled X-Y-Z end mill for cutting the desired miters.

Fig. 9 example of cutting lines with an opening in the bottom of the work piece

Fig. 10 example of shear/cutting lines with end trimmed to enhance feeding

Fig. 11 shear/cutting lines optimized for minimum waste of material

DETAILED DESCRIPTION OF THE INVENTION:

This invention provides numerous methods to enhance a roll-forming machine, such as a gutter machine, to automatically cut a complex profile on each end of the work piece prior to forming the metal. Typically, this would be a 45 degree mitered end, but the invention can accommodate almost any desired profile, including compound angles. The system consists of a microprocessor, a length sensor, optional machining section feed motor, motor control unit and a machining mechanism.

The enhanced roll-forming machine is shown in Fig 1. An overview of the system is shown in Fig. 2. A roll of flat stock material 10, typically light gauge steel or aluminum, is mounted behind or above the machine. It passes between a pair of drive rollers 3 and 4. These are driven by a motor 14. The unformed material passes through a guide mechanism 2, typically two adjustable rollers as is commonly known in the art. A length-monitoring sensor 6, which are commonly known in the art, reports the length to the control computer. This sensor could optionally be part of one of the guide rollers. The unformed material now enters the

machining section. Here the desired profile for the end of the work piece is cut, in this example by a punch 12 and die 13. However, any technique such as a shear, CNC mill, LASER or other common machining method as known in the art could be employed. Two sample profiles are shown in Fig. 7. The cutting path composed of lines 46b, 61b and 60b is machined into the end of the work piece 16 which now passes through another pair of guides 1 and into the forming section of the machine. The desired roll forming lines 15 are also shown as the corners of the cross sectional view in Fig. 6. Note that for clarity not all the fold/bend lines are shown, but one skilled in the art will have no difficulty understanding the drawing. Drive motor 14 is used to power the forming section via a chain 8 or other transmission means. The forming section consists of a series of rollers, starting with roller pair 5, that will form the desired cross sectional shape by bending basically along the folding lines 15. The material will pass the final forming roller 11 and exit the machine in the desired cross section and with the desired profile cut on the end 7. The use of forming rollers is well known in the art and will not be detailed here.

In a second embodiment of the invention, two drive motors are used as shown in Fig. 3. The system diagram for this embodiment is shown in Fig 4. This allows the machining section and the roll forming section to operate independently of each other. This offers numerous advantages that will be described later. The rest of this embodiment is basically the same as that shown in Fig. 1. The first motor 14 feeds material to the machining section; the second motor 19 powers the drive rollers 20 and the forming rollers starting with roller 21. In operation, the controller will request the desired length and configuration; it will then feed the appropriate amount of material into the machining section and either activate the shear mechanism or instruct the operator to do so possibly by turning on indicator light 39. It could also display a message on the output screen 23. Once the first end is cut the controller will feed the material into the forming section where the forming section drive motor 19 will pull the material through until the desired length is reached. Again, the controller will stop the work piece such that the desired cutting point lines up with

the appropriate shear. Once the second end of the piece is cut the controller will feed this piece through the forming section via the forming section drive motor 19. Thus, the length of the next work piece is not required. No material needs to remain in the machine's forming section until another piece is requested.

Another embodiment uses a Computer controlled end mill or similar cutting tool, in the machining section. In addition to all the functions of the previous examples, the system will now be able to perform enhanced functions. This includes cutting any desired angle, compound miters and including tabs for attachment to adjoining pieces. These tabs are shown in Fig. 7 as cutting lines 46a, 60a and 61a. After being roll formed, tabs 60a, 61a and 62a will mate with edges 60b, 61b and 62b respectively and secured with rivets or screws. Edges 46a and 46b will mate and the entire assembly will be sealed with a caulking compound. This results in a strong and watertight joint.

The system shown in Fig 4 may also include control motors 36, 37 and 38, such as stepping motors or servos. These would be part of the CNC machining section shown in Fig 8 and would be used to control the X and Y motion of the milling platform as well as raise and lower the cutting tool assembly 51 in the Z axis to machine the material using the cutting tool 52. Such machining systems are common in the art and will not be detailed here.

The use of a CNC mill also allows non-standard ends to be produced. For example, a coped end could also be cut. In addition, the edge of a work piece could be cut as to match the coped end of the other piece. When connected together the two pieces would result in a "T".

Additionally, holes or slots could be formed anywhere in the work piece. As shown in Fig. 9, this would allow the invention to precut a downspout hole 41. This example also shows a butt end profile 40. Note also that at points 42 the material has not been cut completely across the work piece to enhance feeding through the

roll forming section. The operator would simply cut through this point with a hand tool. It is not expected that this manual operation would be a serious detriment to the invention and would allow the upgrading of existing roll-forming machines that cannot feed material with a square end.

Another embodiment of the CNC solution is envisioned in which only the Y and Z axis stepping motors, would be needed. The controller would use the drive motor 14, to move the material in the X axis. While this requires fewer parts it does complicate both the software and drive motor control circuit.

Another embodiment of the invention is shown in Fig 5. The invention is constructed in a separate unit 34 and attached to an existing roll forming machine 29. The unit 34 would contain a machining section, with the length sensor and control computer that could be attached to an existing roll forming machine. This would allow users to upgrade existing machines. The drive motor 31 that drives rollers 32 of the roll forming machine would be re-wired and controlled by the control unit. Drive motor 32 and drive rollers 33 are optional. While they provide for independent operation of the machining section and the forming section, they do increase cost.

While the invention can cut almost any desired profile several commonly used examples are presented in figures 7, 9, 10, and 11. While several examples will be given the invention is in no way limited to them or to the cutting patterns presented. In fact, it is expected that the desired cutting pattern will be determined experimentally and will be dependant on the desired profile, material being used and the variations between different roll-forming machine sections.

A common profile is shown in Figure 10 being cut into a piece of unformed flat material 16. The desired end shape 18 will result in a 45-degree miter. This end profile also provides for tabs shown as the material left between the desired profile

18 and the cutting path 17 that will be used to attach to the adjoining piece to form a corner or joint. Note that the mating piece would probably not have tabs.

In another enhancement to this embodiment is the addition of a second shear mechanism that would cut profile 44 of Fig. 10. This shear cuts the work piece and trims the corners at an angle to facilitate feeding into the forming section of the machine. This may be required by older existing roll forming machines that need the beveled edges 43 at the start of the work piece in order to feed properly. The main shear or punch would cut the desired profile 17 adjacent to the end. Note that at points 42 the material has not been completely sheared across the material. The operator would cut through at points 42 to remove the guide end of the work piece. This would allow individual pieces to the processed thus reducing waste. Of course, the CNC embodiment of the invention could cut all of these profiles as well.

To operate the invention, an operator enters the desired length and desired profile configuration into the control unit 22 using keypad 24 and display 23. This control unit contains a microprocessor, such as an Atmel 90S8515 or Intel 8051, and necessary control logic as known in the art. The control unit either activates the appropriate cutting mechanism 12 or instructs the operator to do so if the machine isn't equipped with a powered shear. After the first end is cut the control unit engages the drive motor while monitoring the length via the length sensor. Numerous safety features, such as a manual stop button 25 are provided, again, these are common in the field and will not be detailed. The control unit stops the work piece such that the desired length will be obtained once the piece is cut. The controller will need to compensate for the slightly different locations of the shear mechanisms. At this point the controller will either activate the correct shear or instruct the operator to do so. Two options will now be offered to the operator.

First, if a second piece is desired the controller will ask the operator for the length, move the work piece far enough to allow for the required cut, and then feed the remaining section of the first piece. The controller will stop the machine such

that the end of the first piece will just clear the machine. It will then inform the operator that that piece is ready to be cut off. The operator will do this will a hand shears by the cutting the small tabs that leave the pieces connected. The controller will then proceed to process the remaining piece.

The second option occurs if another piece is not immediately required. In this case, the controller will feed the current work piece out far enough to be cut off. It will store this information in non-volatile memory. The next time a work piece is desired the controller will know how much material has already been feed through the machine and will use this information to calculate the correct length. This method is more limited than the dual drive method but it eliminates the need for the miter section feed motor since the material remains a single piece until cut by the operator after forming.

The software that controls the invention could also be interfaced to a computer network 27. The connection could be a standard Ethernet connection as is common in the art or a wireless interface. This would allow the system to download a series of pieces to be formed without requiring the operator to individually enter each one. Conversely, it could record the number and lengths of the pieces formed and upload this to the network. In addition, by knowing the number and configuration of pieces desired, the computer could reduce waste by optimizing the order in which pieces are produced. It would sequence pieces such that opposing mitered ends are done adjacent to each other as shown in Fig.11. Here the end of work piece 16 is cut adjacent to work piece 47. Numerous other possibilities exist and are obvious to those skilled in the art.

It has been found while implementing this invention that the computer 22 may need to turn off the drive motor 14 before the actual desired position is reached since the roll-forming mechanism does not stop instantly. The amount of 'drift' in a roll-forming machine is dependent on the type and thickness of material being formed, condition and design of the roll-forming section and numerous other

variables. A 'drift factor' in the system software accounts for the error. This drift factor may be a programmed constant or may be dynamically adjusted as follows. When the controller turns off the drive motor it continues to monitor the amount of material that has actually moved past the length sensor 6. This is a measure of how much drift this particular machine has. This measurement can be used to modify the drift constant. This procedure can also be used before the end of the work piece is reached. By shutting down the drive motor 14 before the end is reached the computer can measure and adjust the drift factor for that individual work piece. The controller would then restart the drive motor and position the work piece at the proper location using the new drift constant.

It is envisioned that numerous combinations of the features presented in this document could be built. Nor is the invention limited to any particular method of machining the material. It could also be applied to non-metallic work pieces.

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